KNOCK OUT HYDROGEN SULFIDE WITH LO-CAT®

H_2S

COMPLETE PACKAGED SYSTEMS FOR COST-EFFECTIVE HYDROGEN SULFIDE REMOVAL

Gas Technology Products
Merichem Chemicals & Refinery Services LLC

LO-CAT®

A COST-EFFECTIVE, ENVIRONMENTALLY FRIENDLY WAY TO REMOVE H_2S FROM ANY GAS STREAM

H_2S

While we enjoy the fresh scent of pine forests and spring flowers, not all nature's smells are pleasant. The odor of hydrogen sulfide gas is downright offensive. But hydrogen sulfide is more than just a bad smell. It can be bad for the environment. It can be bad for the bottom line. It can be deadly.

Hydrogen sulfide is primarily a nuisance odor for wastewater treatment plants and facilities with reverse osmosis systems. But it's a nuisance that can't be ignored as residential areas encroach on once-remote plants and environmental regulations mandate odor control.

For other industries, it's more than just a bad smell. Hydrogen sulfide can be a natural component of any source of energy – natural gas, oil, geothermal steam, biogas, synthesis gas, etc. When burned, hydrogen sulfide (H_2S) forms sulfur dioxide (SO_2) – a precursor to acid rain – bringing with it the legacy of dying trees, crumbling structures, acidic surface waters… and not just in our own backyard. SO_2 is itself the subject of regulatory concern.

Even beyond the environmental problems, hydrogen sulfide is a headache for industry. H_2S becomes highly corrosive when, combined with water, it forms sulfuric acid and literally eats away at metal.

Hydrogen sulfide is a deadly poison – immediate loss of consciousness and death in as little as 30 minutes results from exposure to 500 parts per million of H_2S in air.

It's more than just a bad smell.

Gas Technology Products' **LO-CAT**® process is a cost-effective, environmentally friendly way to remove hydrogen sulfide from any gas stream.

LO-CAT®

LICENSEES OF THE LO-CAT® HYDROGEN SULFIDE OXIDATION PROCESS

OIL & GAS PRODUCTIONS

AGIP, SpA, Italy (AAG)* (2 units)
Alberta Nat'l Gas (AAG), Canada
Amoco Prod. Co. (EOR)* (3 units)
Amoco Oil & Gas Well Prod.
Arco Oil & Gas (EOR) Plains, TX
Atco Gas Services Ltd., Canada
(AAG)
Chemco, Mech. (NG)
Chevron Pet. Tech (AAG)
Chevron U.S.A. (EOR)
Corporven, S.A. (AAG)
Exxon Company (AAG) (2 units)
Exxon U.S.A. Inc. (AAG)
Hewitt Oil Co. (NG)
Hungarian Nat'l Oil (NG)
INA Naftaplin, Croatia (AAG)
Kuwait Petroleum
(ship unloading-loading vapors)
Lagoven, S.A. (NG)
Marathon Oil (NG)
Mobil Oil Canada (EOR)
Ellwood (Stretford conversion)
Mobil Oil Baskerfield (WHGC)*
Oil & Natural Gas Commission of
India (AAG) (3 units)
Petroelum Authority of Thailand
- PPT (NG)
Pinnacle Gas Treating (2 units) (AAG)
Rigel Oil & Gas, Canada (AAG)
Samson Resources Co.(AAG)
(2 units)
Shell Oil Co.
Tejas Gas Corp. (AAG)
Tri-link Resources Canada (AAG)
Undisclosed, Tunisia (AAG)
Union Pacific Resources Co.
(Steam flood oil prod.)
Western Gas (2 units) (AAG)

BIOGAS APPLICATIONS
FROM ANAEROBIC DIGESTERS

Boston Harbor
City of Los Angeles/Hyperion
Ellesmere Port, England
Port Adelaide, Australia
Red Star Yeast
South West Water, Hayle, England
Thames Water, Hogsmill, England
Thames Water-Wargraave, England
Wessex Water, Berryhill, England

COKE OVEN GAS DESULFURIZATION

Geneva Steel, Utah
Inland Steel (Pilot Plant)

CO_2 PURIFICATION

Consorgas S.r.L. (2 units), Italy
Praxair
Argentina
China
Mexico
Thailand (3 units)
U.S. (2 units)
Mitsui Toatsu Chemicals, Japan

GEOTHERMAL STEAM PROD.

California Energy Navy I & II
California Energy Navy II Expansion
Himpurna California Energy Inc.,
Indonesia
CE Cebu Geothermal Power,
Philippines
Visayas Geothermal Power Co.,
Philippines
UMPA, Utah Municipal Power

OIL REFINERY

Cochin Refinery, India (AAG)
Daelim Ind. Co. Ltd., Korea (AAG)
HPCL, India (AAG) (2 units)
Irish Refining, Ireland (FG)*
Koch Refining
Mobil Altona Refinery, Australia
Pennzoil Products (FG)
Petromin Lubricating Oil Refinery
Co. (AAG), Saudi Arabia
Star Enterprises (Texaco) (Asphalt)
U.S. Oil & Refining (FG)
Witco Oil (FG)
Wyoming Refining (FG)

MUNICIPAL WWTP ODOR CONTROL

City of Cappelle, Holland
City & Country of Honolulu, HI
(3 units)
Honouliuli WWTP
Kailua WWTP
Sand Island WWTP
City of Riyadh, Saudi Arabia
City of Winnipeg, Canada (2 units)
Fort Kam, Hawaii
Yorkshire Water, Rawcliffe, England

VENTILATION AIR APPLICATIONS

Martin County, Florida (RO)*
Red Star Yeast
Santa Barbara Water District
Business Park
Shanks & McEwan, Stewartby,
England
Town of Jupiter, Florida (RO)*
Westvaco Polychemicals
Zincor, So. Africa

OTHERS

BHP, Australia (hot briquetted iron)
ESD-Elektrochmelzwerk Delfzijl
B.V., Netherlands
(silicon carbide smelting)
Kronos International, Inc.,
Germany (TiO_2 production)
Louisiana Pigment, LA
(TiO_2 production)
Lubrizol, France (lube oil additives)
(2 units)
Orinoco Iron, Venezuela
(hot briquetted iron)
Praxair, Canada
(H_2S bottling)
Schumann/Sasol, Germany
(wax hydrogenation)
Texasgulf (phosphoric acid)
Viskase, Illinois
(Viscose production)
WMX, Florida (landfill gas)

REFERENCES

***AAG -**	**Amine Acid Gas**
***EOR -**	**Enhanced Oil Recovery**
***FG -**	**Fuel Gas**
***RO -**	**Reverse Osmosis**
***NG -**	**Natural Gas**
***WHGC -**	**Well Head Gas Casing**

LO-CAT®
APPLICATIONS

Anaerobic

Aerobic

Autocirculation

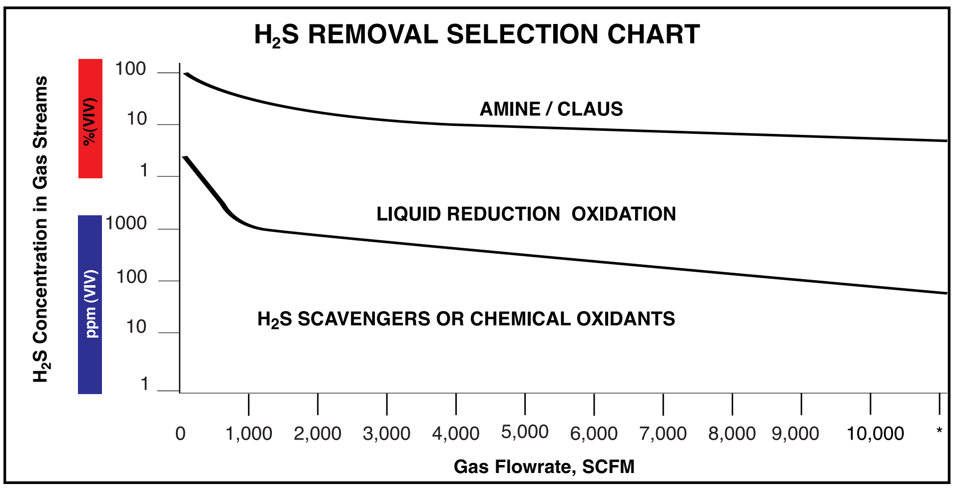
LO-CAT® systems have proved themselves in several industries, including oil and gas production, biogas from anaerobic digesters, coke oven gas desulfurization, CO_2 purification, geothermal steam production, oil refining, odor control for municipal wastewater treatment, landfill gas, ventilation air treatment, and others.

Anaerobic Processes include LO-CAT® units for natural gas, refinery fuel gas, sour water stripper gas, synthetic gas from coal gasification, steel mill/coke oven gas, sewage plant digester gas, claus tail gas, CO_2 production, and EOR.

Aerobic Processes include LO-CAT® units for manufacturing process vents, sewage plants, wastewater treatment, and process effluent.

Autocirculation Processes include LO-CAT® units for amine acid gas, chemical plants, and geothermal non-condensible gases.

As you can see on the chart below – liquid reduction oxidation fits between amine/claus and H_2S scavengers or chemical oxidants.



* Our general range is between 150 lbs of sulfur per day up to 20 long tons per day.

Gas Technology Products have solid, liquid and regenerable catalyst systems to custom tailor sulfur removal solutions up to 30+ tons per day.

THE LO-CAT® SOLUTION

Prompted by strict air pollution regulations and a greater concern over hazardous wastes, today's improving technology makes hydrogen sulfide removal more economical than ever.

The LO-CAT process is a patented, wet scrubbing, liquid redox system that uses a chelated iron solution to convert H_2S to innocuous, elemental sulfur. It does not use any toxic chemicals and does not produce any hazardous waste byproducts. The environmentally safe catalyst is readily available and since it's continuously regenerated in the process, less catalyst is used, more money is saved. This state-of-the-art technology is listed by the Environmental Protection Agency as maximum achievable control technology (MACT).

The LO-CAT technology is applicable to all types of gas streams including air, natural gas, CO_2, amine acid gas, biogas, landfill gas, refinery fuel gas, etc. The liquid catalyst adapts easily to variations in flow and concentration. Flexible operation allows 100% turndown in gas flow and H_2S concentrations. Units require minimal operator attention.

LO-CAT units can be designed for better than 99.9% H_2S removal efficiency.

LO-CAT. Reliable. Efficient. Economical.

LO-CAT® TOTAL PACKAGE

From engineering and design, to training and startup, through process warranties and service, we provide a Total Package. We will build to your specifications and meet your tight schedules. We provide optional turnkey projects and installation supervision.

We guarantee H_2S removal efficiency, removal capacity and chemical consumption rate. We also guarantee the continued availability of system catalyst.

We provide on-going technical service, analytical service, trouble-shooting assistance, operator training and refresher courses, annual user's seminar, technical information exchange and patent grant back program.

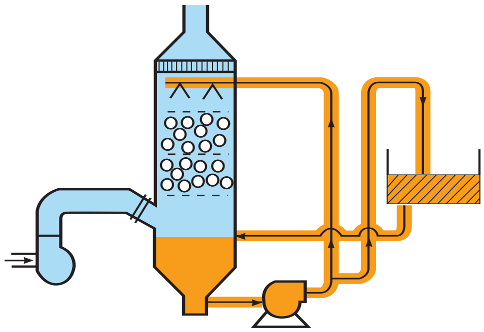
* LO-CAT and LO-CAT II are registered trademarks of Gas Technology Products.

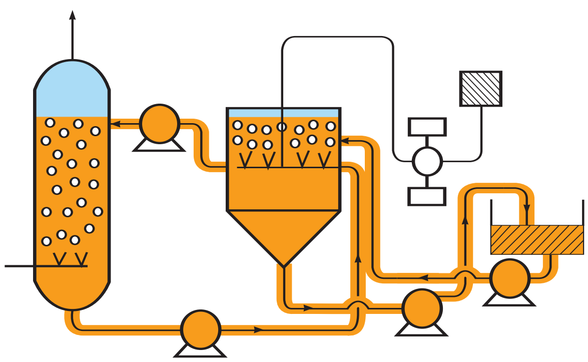
The differences between the LO-CAT process and the LO-CAT II Process are in design. For certain applications the advanced mechanical design of LO-CAT II is appropriate.

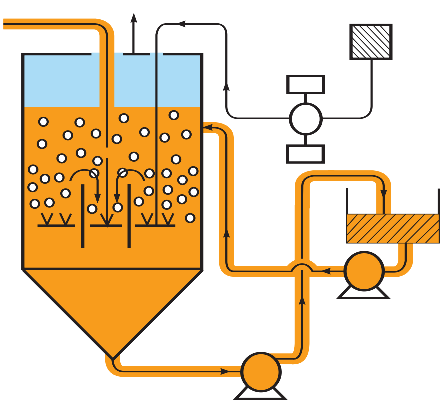
H_2S

LO-CAT®

HOW THE SYSTEM WORKS







AEROBIC

The aerobic design is used where odor control is the primary concern. Typically, the air stream is discharged to atmosphere once the H_2S is removed.

Hydrogen sulfide laden air enters the absorber vessel where it comes in contact with the LO-CAT catalyst solution. The almost-instantaneous chemical reaction produces solid sulfur, which is filtered out of the catalyst solution. Oxygen present in the air stream continually regenerates the catalyst, which is used over and over again.

Air stream flowrate and H_2S concentration determine the size of the absorber. Units can be designed to handle air flow rates from a few hundred to several hundred thousand scfm and H_2S concentrations from 50 ppmv to several thousand.

ANAEROBIC

Designed to remove H_2S from anaerobic gas streams or when product recovery is desired, this LO-CAT design feature separates the absorber and oxidizer vessels. H_2S removal and conversion to solid sulfur takes place in the absorber. Reduced catalyst solution is circulated to the oxidizer and regenerated by contact with air.

Various types of sulfur handling equipment are used to remove the solid sulfur from the LO-CAT system, depending on the amount of sulfur produced. For units producing less than 1,000 lbs of sulfur per day, a bag filter system is used, which produces a 30 wt% sulfur cake. For larger units, a settler/belt filter system is used, which produces a 60 wt% sulfur cake. If desired, the belt filter cake can be melted, producing molten sulfur.

AUTOCIRCULATION

This patented system offers cost-effective treatment of anaerobic, non-explosive gas streams. Once the H_2S is removed, the sweet gas stream along with the oxidizing air is discharged to the atmosphere rather than recovered. Since the chemical reactions all occur in a single vessel, the Autocirculation process needs no catalyst circulation pumps and uses very low concentrations of catalyst.

This technology is very effective for treating effluent from amine acid gas extraction processes in natural gas production plants and the non-condensible gases released from geothermal power production.

LO-CAT®

STATE-OF-THE-ART IN REDOX CHEMISTRY TECHNOLOGY

The basic chemistry is the same for all three system configurations. H_2S is converted to innocuous, elemental sulfur using an environmentally safe, chelated iron catalyst. The iron catalyst is held in solution by organic chelating agents that wrap around the iron ion in a claw-like fashion, preventing precipitation of either iron sulfide (FeS) or iron hydroxide ($Fe(OH_3)$). The LO-CAT process is based on reduction-oxidation (Redox) chemistry. Two different Redox reactions take place – one in the absorber section, which converts the H_2S to elemental sulfur, and one in the oxidizer section , which regenerates the catalyst.

ABSORBER REACTIONS

$$H_2S\ (g) + H_2O\ (liq) \longleftrightarrow H_2S\ (liq)$$

$$H_2S\ (liq) \longleftrightarrow HS^- + H^+$$

$$HS^- + 2Fe^{+++} \longrightarrow S^\circ(solid) + 2Fe^{++} + H^+$$

In the absorber, H_2S is absorbed into the slightly alkaline, aqueous LO-CAT solution. The H_2S ionizes to bisulfide, which is oxidized to sulfur by reducing the iron ion from the ferric to the ferrous state. The reduced iron ions are then transferred from the absorber to the oxidizer.

OXIDIZER REACTIONS

$$\tfrac{1}{2}\ O_2(g) + H_2O(liq) \longleftrightarrow \tfrac{1}{2}\ O_2(liq)$$

$$\tfrac{1}{2}\ O_2(liq) + 2Fe^{++} + H_2O \rightarrow 2Fe^{+++} + 2OH^-$$

In the oxidizer, atmospheric oxygen is absorbed into the LO-CAT solution. The ferrous iron is reoxidized to ferric iron, regenerating the catalyst. The regenerated catalyst is ready for use in the absorber section.

OVERALL REACTIONS

$$H_2S\ (g) + \tfrac{1}{2}\ O_2(g) \longrightarrow H_2O + S^\circ$$

The overall reaction is an isothermal, low operating cost method of carrying out a modified Claus reaction. The chemical additions required to maintain the above reactions are caustic for maintaining the pH, replacement of chelated iron lost in the sulfur removal process, and replacement of degraded chelating agents.

SIDE REACTIONS

Thiosulfate Formation

$$2HS^- + 2KOH + 3/2O_2 \longrightarrow K_2S_2O_3 + 2H_2O$$

Biocarbonate Formation

$$CO_2(g) + H_2O(liq) \longleftrightarrow H_2CO_3(liq)$$

$$KOH + H_2CO_3 \longleftrightarrow KHCO_3 + H_2O$$

As with any chemical process, side reactions can occur during the LO-CAT process. For example, thiosulfate formation increases greatly when oxygen is present in the sour gas. This occurs when the sour gas being treated is an air stream or when the sour gas has been contaminated with air. Thiosulfate does have some benefits in the process in that it stabilizes the chelating agents, reducing degradation and thereby reducing chemical costs. On the other hand, too much thiosulfate requires the addition of caustic to maintain pH. Blowdown may be required to avoid salt buildup in the system.

Biocarbonate formation depends on the amount of carbon dioxide absorbed from the sour gas, which depends on the CO_2 partial pressure and the pH of the solution. There are no benefits to biocarbonate formation. Caustic must be added to maintain pH and some of the CO_2 is lost.

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